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Yin, Y., Thwaites, K. orcid.org/0000-0002-2597-4544 and Shao, Y. (2022) Balancing street functionality and restorative benefit : developing an expectation–current approach to street design. *Sustainability*, 14 (9). 5736.

<https://doi.org/10.3390/su14095736>

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Article

Balancing Street Functionality and Restorative Benefit: Developing an Expectation–Current Approach to Street Design

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Abstract: The importance of creating a better living environment that is conducive to public health has become increasingly prominent in the post-epidemic era. The restorative potential of urban streets has been emphasized recently, as these spaces of our everyday lives may provide people with restorative experiences. However, there is still no efficient way of delivering restorative street design, because no specific standard has been set to indicate the form such streets should take. A street has limited spaces but multiple uses; hence, the delivery of restorativeness is largely restricted by street contexts. This research proposes that this standard should be determined by the balance between street functions and restorative benefits. An expectation-current approach that involves street functions, street typologies, restorative evaluations and users' expectations was developed in conjunction with its application to four pairs of streets. Each pair included one typical street type determined by its inherent function, and one corresponding case-study street. The restorative expectations and the streets' current levels of restorativeness were evaluated, and their differences were used to indicate how and to what degree street-related restorative benefits should be optimized. Restorative design implications of the four case-study streets were then summarized accordingly. The expectation–current approach not only serves as a rigorous and sustainable method by stressing the balance between street functions and restorativeness, but also has the potential for application in broader assessment studies, especially when multiple environmental qualities need to be considered, with the advantage of the extensive involvement of people.

Keywords: street function; restorative benefits; expectation; current evaluation; optimization



Citation: Yin, Y.; Thwaites, K.; Shao, Y. Balancing Street Functionality and Restorative Benefit: Developing an Expectation–Current Approach to Street Design. *Sustainability* **2022**, *14*, 5736. <https://doi.org/10.3390/su14095736>

Academic Editor: Giouli Mihalakakou

Received: 15 April 2022

Accepted: 7 May 2022

Published: 9 May 2022

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1. Introduction

Over 75% of the world's population has experienced prolonged home confinement during the COVID-19 pandemic, resulting in a higher occurrence of psychological issues, such as depression, anxiety and insomnia [1]. The importance of creating a better living environment that is conducive to public health has become increasingly prominent in the post-epidemic era. In this context, restorative places that are beneficial to human mental health are regarded as essential in urban everyday life. This is particularly true when a common open space possesses restorative qualities, meaning they can help people recover as part of their everyday lives. The restorative benefits of urban streets have, therefore, attracted a lot of academic attention in recent years due to the high proportion of acreage they take up in urban areas, as well as the inevitable role they play in the outdoor lives of city dwellers [2,3]. However, the efficient delivery of restorative street design is still limited, as no specific standard has been set to offer instructions regarding how restorative a street should be. Starting with a recognition on streets as complicated urban spaces with multiple uses, this study intends to develop a design approach that considers the balance between street functions and restorative benefits. To avoid excessive design and

socioeconomic expenditure, this approach works with a strict standards of appropriate street restorativeness improvements, and is hence believed to be in line with sustainable urban-development goals.

1.1. Studies of Restorative Streets

The concept of a restorative environment was first conceived to emphasize the healing aspect of nature. Earlier studies proved that humans possess an inherent need and desire to connect with nature on a psychological level [4–6]. It was found that the restorative benefits of nature are inherent in its ability to provide people with a sense of *being away*, a sense of *extent* that suggests more opportunities, *fascination* and a degree of *compatibility* [6,7]. Research attention has subsequently moved on to reveal the restorative benefits of urban environments dominated by natural characteristics, such as parks [8], gardens [9] and waterscapes [10]. However, there is no evidence to suggest that these environmental features can only be observed in nature or nature-dominated settings [11]. Indeed, streets, as one of the most common urban public spaces [12], have attracted increasing research attention, as they play multiple roles in everyday life and are among the major places where people carry out their outdoor activities [13]. Differing from more natural restorative destinations (e.g., mountains, forests and parks), people do not intentionally use streets for restorative needs. Restorative street experiences are easily accessible resources and, in most cases, are provided by urban streets as supplementary benefits alongside people's normal activities when they are meeting friends, shopping and taking a walk.

Previous studies have shown that well-designed street environments can help people replenish their depleted psychological resources during the everyday grind of working and living. This positive process involves reducing their stress levels, restoring themselves after suffering mental fatigue and arousing positive physiological and emotional responses [14–16]. To explore possible ways of enhancing street restorative benefits and to deliver restorative street design, most relevant literature endeavors to identify street design indicators relating to restorativeness. Research findings have confirmed that trees, flower beds and other natural elements on the verges of residential streets can have a positive impact on people's emotional states [17,18]. Furthermore, increases to the visibility of greenery can significantly enhance the restorative potential of urban streets, which consequently improves the mental health status of street users [18]. In addition, the openness of the street environment has been proven to be positively related to street restorativeness, while enclosure and entropy (disorder in the elements of the street environment) have been found to be linked to a negative influence in this regard [19].

Nevertheless, the delivery of restorative street design in design practices has so far been restricted, due partly to the lack of a specific standard instructing how restorative a street should be. Recently, a new perspective for considering street restorativeness has emerged via a series of studies [2,20]. When collated together, these studies seem to argue that the design of street restorativeness should be balanced with other qualities associated with inherent street functions, since urban streets are not created simply for leisure purposes. Instead of complying with merely better standards, the achievement of street restorativeness may require standards more in line with urban sustainable development goals. Indeed, the standards could be an important prerequisite for optimizing restorative benefits to a necessary extent, without threatening the dominant functions and corresponding qualities of streets. Referring to a precedent set in an explorative study on measuring the restorative expectations of different street types [21], this investigation underlines the relation between street functions, street types and users' restorativeness expectations as the central concern when improving street restorativeness.

1.2. Street Functions, Street Types and Users' Restorativeness Expectations

Primary function is often a key factor when categorizing urban streets, and is reflected in street classification systems, differentiated design methods and associated street design practices [22]. For example, even with the same purpose of enhancing street vitality, design

focuses may vary in relation to landscape-focused streets and their commercial counterparts. Exercise and leisure facilities may be necessary considerations regarding landscape-focused streets, while design suggestions may focus on the variety of street frontages and the type of vegetation in commercial streets. In relation to this, three factors are assumed to be important when appropriately optimizing street restorative benefits: restorativeness expectations regarding different street types, and people's restorativeness evaluations of the different types of streets and the differences between them. An individual's restorativeness expectations of different street types determine the kinds of restorative experiences they anticipate having in certain streets that have obvious dominant functions. For example, people might expect a higher level of restoration when they walk along a landscape-focused street as opposed to one that mainly sustains traffic movement.

In fact, a few restorative environment studies have attempted to compare the restorative potential of different types of places. These research examples include attempts to make comparisons between different types of natural environment [23], natural and urban environments [24] and urban settings with different functions [9]. However, a limited amount of attention has been paid to differentiating the level of restorativeness between subtypes of the same kind of environmental setting. To date, research efforts have only compared the restorative potential of formal/informal gardens [25] and of commercial and traffic-oriented streets [20]. Similar attempts have also been made to measure and differentiate the restorativeness expectations regarding four different types of streets in Shanghai with distinctive functional characteristics [21]. Although recent restorativeness studies have begun to show an in-depth understanding of the uniqueness of each street environment, there is still a lack of discussion on the possibility of utilizing the gap between the expected degree of street restorativeness and related evaluations, as well as using the restorative differences between street types, to enhance the restorative potential of these urban spaces. Such endeavors could also provide straightforward instructions for their design practices.

2. The Expectation–Current Approach

This study aims to find a way of optimizing the restorative benefits of streets appropriately; that is, improving restorativeness without adversely affecting the realization of street qualities linked to their functional values. From an innovative viewpoint of aiming to progress street restorativeness based on the difference between people's expectations and their evaluations of the current level, this study develops an expectation–current approach. It differs from existing restorativeness-measurement methods, as it not only measures environmental restorativeness, but indicates how much restorativeness people expect, and whether the current environment meets their requirements. By setting users' expectations as the restorative optimization standard, the expectation–current approach succeeded in: (1) achieving street restorative benefits in line with street functions, (2) deeply involving people's wishes in the process of improving environmental quality, and (3) providing specific design implications for restorative street-design practices.

The expectation–current approach included the use of a survey questionnaire, which was developed with restorativeness psychometrics to investigate the expected and the current levels of street restorativeness; then, the differences between the two values were compared to show what the necessary improvements should be. In Yin's study on street restorativeness expectations, the relevant psychometrics were edited into an online version to obtain users' expectations regarding street-restorativeness levels [21]. An on-site survey was also adopted to collect respondents' evaluations with regard to the current level of street restorative benefits. As stated above, street functions and types are important in determining how these benefits should be delivered. Hence, design implications for improving street restorativeness that were generalized according to the discrepancies between expected and the current street benefits were collected for each street pairing, i.e., the street type and its corresponding street.

2.1. Measurements

The survey questionnaire included two sections, and was used for both the online and the on-site survey. The main section adopted the Restorative Components Scale (RCS) [26] to measure related expectations and evaluate street restorativeness. The RCS was developed based on the Perceived Restorativeness Scale, a widely used instrument for measuring environmental restorative benefits [27]; however, the RCS offers a more consistent factor structure that is in line with attention restoration theory (ART) [26]. Four environmental dimensions—*being away*, *extent*, *fascination* and *compatibility*—were proposed in the development of ART as necessary elements when delivering restorative experiences [6]. They were later commonly used as the conceptual basis for developing restorative measurements [28,29]. The RCS (Table 1) was selected as the measurement scale for this study because its feasibility for investigating both the expected and the current level of street restorativeness has been validated in previous investigations [2,21]. After the RCS, the second section was designed to collect the personal information of the subjects, including their gender, age and professional background, to test for any individual perceptual differences.

Table 1. The Revised Restorative Component Scale Used in this Study [21].

ART Dimensions	RCS Statement
Being Away (B)	B1—When I am here, I feel free from my work and daily routine. B2—When I am here, I feel free from other people’s demands and expectations. B3—When I am here, I do not need to think of my responsibilities and obligations.
Extent (E)	E1—The elements here go together. E2—The existing elements belong here. E3—The surroundings are coherent.
Fascination (F)	F1—There is plenty to discover here. F2—This setting has many things that I wonder about. F3—There are many objects here that attract my attention. F4—There is plenty that I want to linger on here. F5—I am absorbed in these surroundings.
Compatibility (C)	C1—The environment gives me the opportunity to do activities that I like. C2—I can handle the kinds of problems that arise here. C3—I can rapidly adapt to this setting. C4—There is an accordance between what I like to do and this environment.

2.2. Stimulus

The expectation-current approach was developed and applied in Shanghai, since it has a developed street system composed of diverse types of streets [22]. Four street pairs in the city, each including one street type determined by its inherent function and one corresponding case-study street, were selected for validation of the optimization approach. The categories of street types were investigated in line with restorativeness expectations, while case-study streets were measured in relation to their current restorativeness levels. The difference between the restorativeness expectations and the current level of restorativeness was analyzed responsively to ascertain how to improve the restorative benefits of the four case-study streets and to generalize restorative design implications accordingly.

2.2.1. Stimuli for Restorative Expectation Research

There are five major street types in the Shanghai Street Classification System that are categorized according to their functions and characteristics. However, only four of these types—the commercial street, the living and service street, the landscape and leisure street and the traffic-oriented street—were investigated in this study, as the fifth type, the comprehensive street, integrates all of the other types [22]. Textual descriptions of the four street types (Table 2) were used in the online survey with regard to the environmental stimuli in order for people to respond with their restorativeness expectations. To avoid

potential bias, the online questionnaire did not provide any pictures or names of specific streets as examples.

Table 2. Street Type Definitions in Shanghai Street Design Guidelines [22].

Street Types in Shanghai	Definition and Description
Commercial street	This type of street is dominated by retail, food services and other commercial businesses, and has a certain level of service capability and industrial attributes.
Living and service street	This type of street is dominated by residential services, small and mid-scale retail, food services and other businesses, as well as public facilities.
Landscape and leisure street	This type of street is characterized by waterfront, landscape, or historical characteristics, and equipped with leisure and entertainment facilities.
Traffic-oriented street	This type of street is dominated by traffic-volume functionality, with mostly closed frontages.
Comprehensive street	This type of street mixes all street types and frontage types, or contains more than two characteristics.

2.2.2. Stimuli for the Current Street Restorative Evaluation

Four case-study streets—University Road, Sujiatun Road, Zhangwu Road and Guokang Road—in Shanghai were selected to respectively represent the aforementioned typical street types. University Road is a well-known commercial street surrounded by mixed commercial and office land uses, with a knowledge and innovation community located one block away. It is also regularly utilized by people working nearby when they take their lunch breaks. The eastern end of University Road connects with a metro station, which also makes it an optional commuting path towards the west-side residential blocks of the street. Furthermore, it is a street with commercial frontages along both sides, including cafes, restaurants, bakeries and various retail shops. These street frontages are normally decorated with windows, flowers and greenery. Outdoor seats with sunshades are provided by most ground-floor retailers to attract customers; this creates opportunities for stationary activities (see Figures 1 and 2).

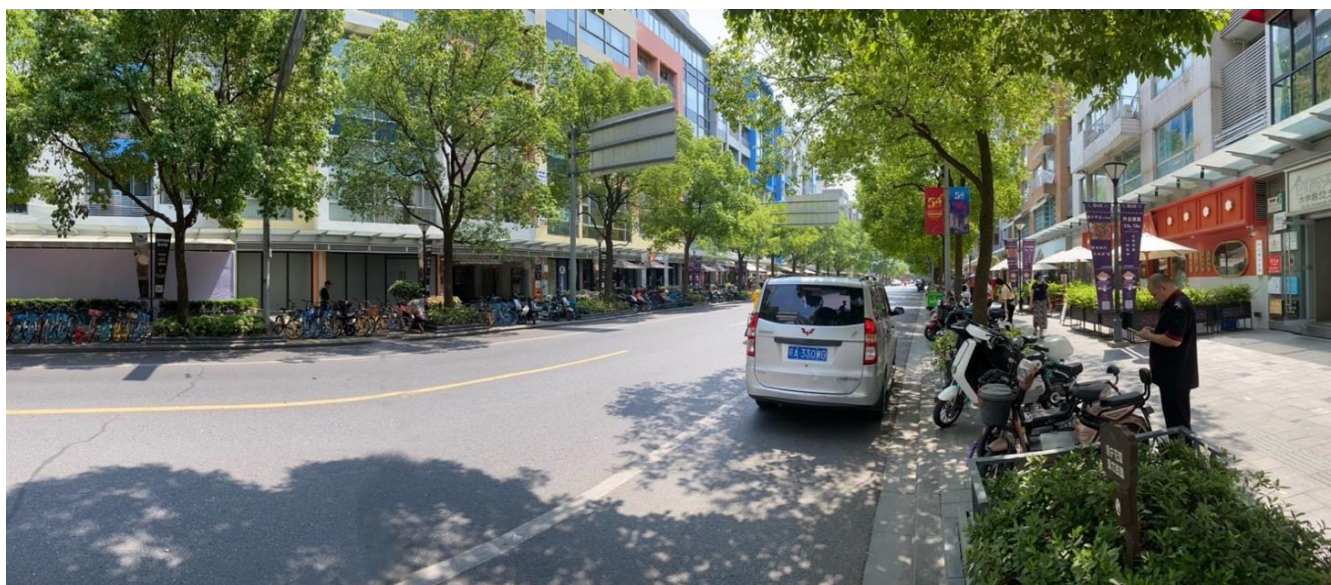


Figure 1. Panoramic photo of University Road (source: the author).

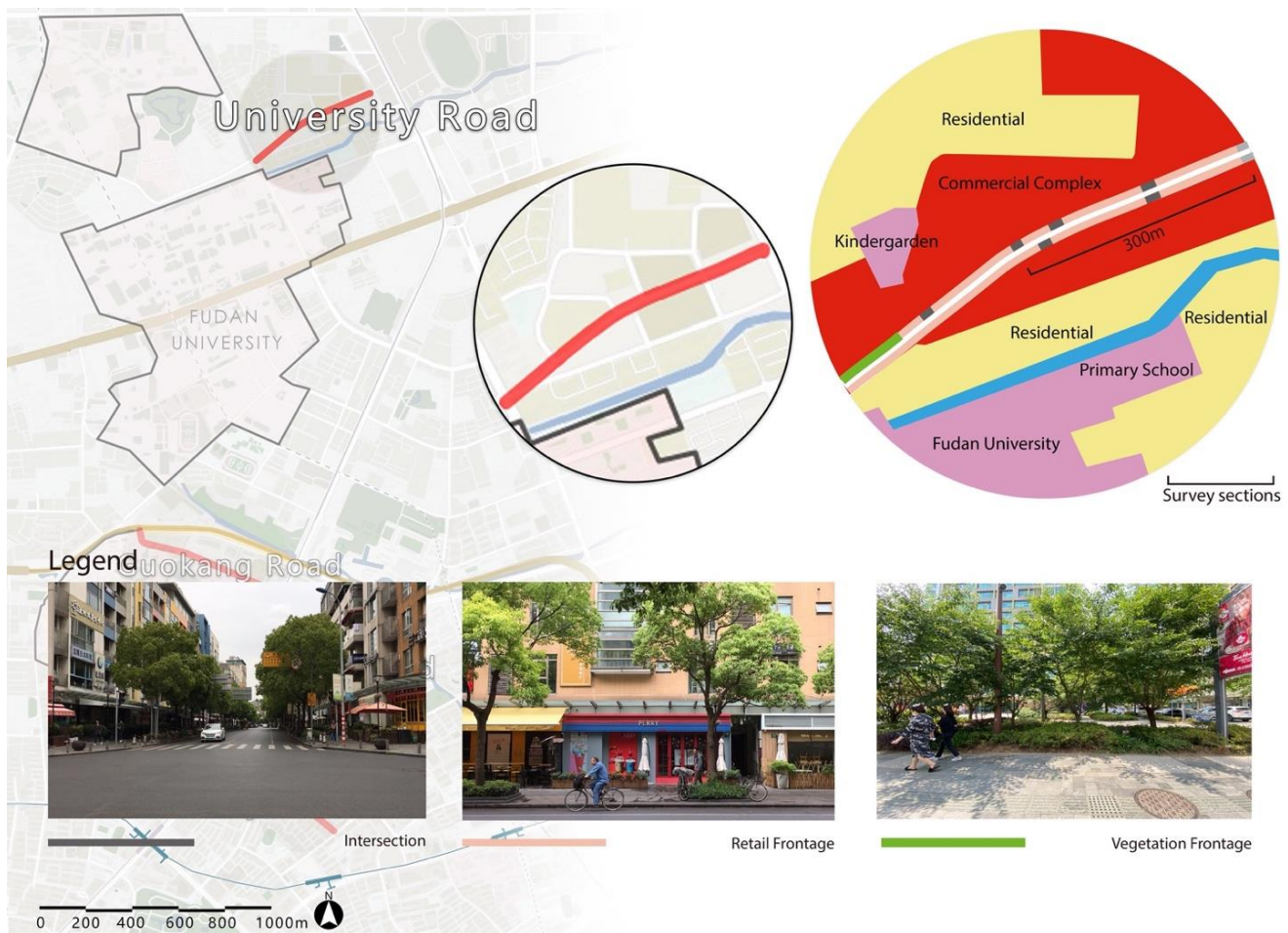


Figure 2. Site condition of University Road (source: the author).

Meanwhile, Sujiatun Road is characterized by landscape features, and is surrounded by purely residential buildings with well-designed green landscaping along both sides; thus drawing many nearby residents to spend their leisure time and undertake exercise there. Furthermore, it is a commuter pathway, linking its south-end metro station to residential blocks and to its north-end office buildings. Sujiatun Road has dense trees along both sides, and there are various types of flowers and shrubs functioning as decorations. The street frontages are similar on both sides and are interspersed with pocket parks and greenery. Two small-scale pocket parks are located on the west side of the street, and a larger one can be found on the east. There is also a residential greenway located on the east side of Sujiatun Road, next to the pedestrian paths. Seats and exercise facilities are set along the street's sides and within the pocket parks. There is a metro station one block away (200–300 m), with a walk of about 10–15 min to nearby office building blocks (see Figures 3 and 4).

Guokang Road is located on the northern side of a university campus, and its own north side also abuts several office blocks. There are two bus stops on this street, and it is also linked to the nearest metro station 800 meters away, which mainly serves the commuting needs of university staff and people who work in the surrounding office buildings. Therefore, Guokang Road was selected to represent a traffic-oriented Street. Its south-side frontage is dominated by the fences of the university campus, and there are two types of frontages on its east side: the fences of the surrounding office blocks and greenery. The university fences are made of red bricks and iron bars, while the office block's fences are simple iron examples. The street-side greenery consists of trees, shrubs and herbaceous plants (see Figures 5 and 6).

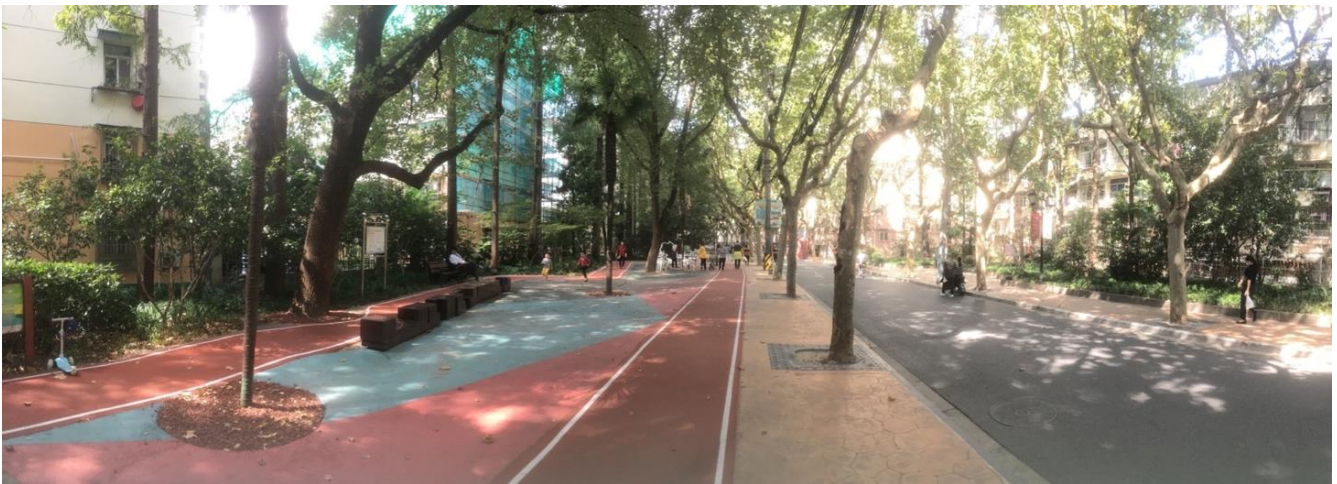


Figure 3. Site condition of Sujiatun Road (source: the author).

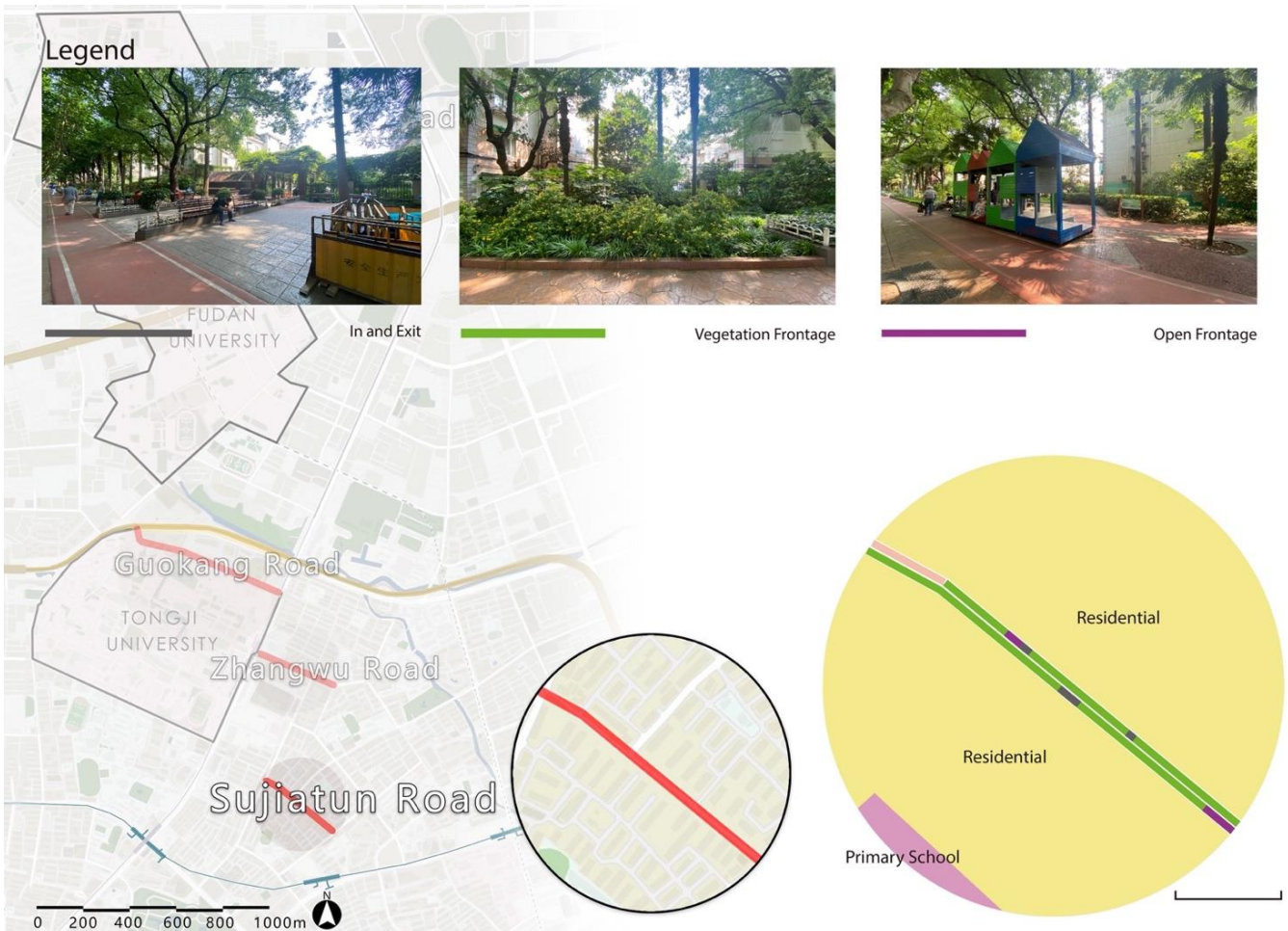


Figure 4. Site conditions of Sujiatun Road (source: the author).



Figure 5. Panoramic photo of Guokang Road (source: the author).



Figure 6. Site condition of Guokang Road (source: the author).

Zhangwu Road is a typical living and service street with residential neighborhoods located on both sides. Trees are planted along both sides of the street, and there is a well-designed greenbelt of vegetation featuring shrubs and flowers. There are four types of street frontages on Zhangwu Road that mainly include the walls of surrounding residential blocks, retail shops with no provided setback, retail shops with setbacks and street-side greenery composed of trees and shrubs. In addition, there is a small-scale commercial area

for the neighborhood, which encompasses restaurants and living services at the western end of the road. This has generated a larger setback space that is decorated with greenery and resting spaces (see Figures 7 and 8).



Figure 7. Panoramic photo of Zhangwu Road (source: the author).

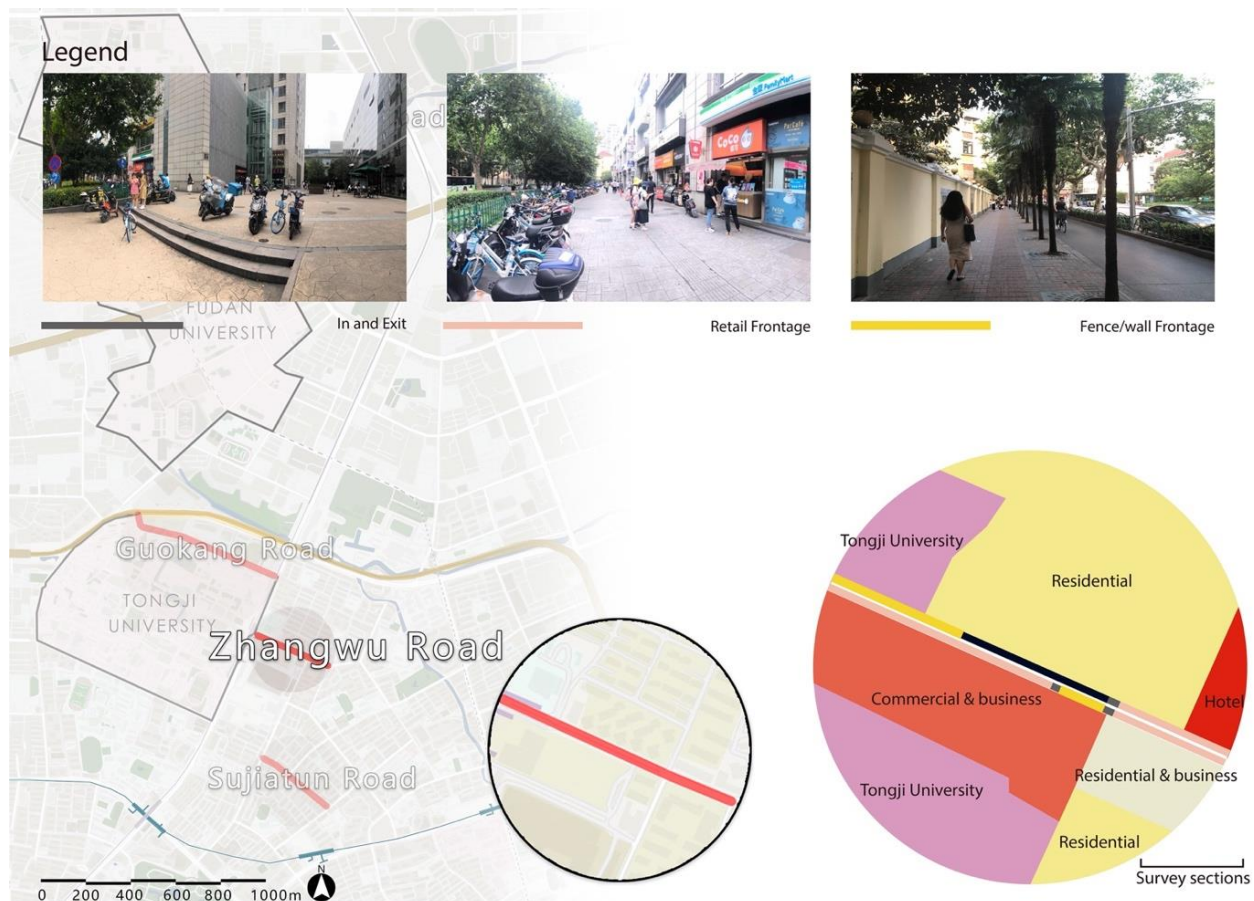


Figure 8. Site conditions of Zhangwu Road (source: the author).

2.3. Procedures

This study consisted of two stages. The first stage involved using an online social platform to disseminate the questionnaire survey in order to obtain expectation ratings in relation to the four street types. The RCS questionnaire was edited into an online version

using the Wenjuanxing website [see <https://www.wjx.cn/> (accessed on 5 June 2019)], an online open platform that is used for designing, editing and promoting questionnaires and surveys. By publishing and forwarding the questionnaire link across different social networks, it can be effectively delivered to a large population group with minimum time and economic costs. WeChat was selected as the major platform for spreading this questionnaire due to its high number of active users across all social apps in China. When participants clicked on the survey link, they were first shown a brief introduction to the survey and were asked to sign the consent form if they were willing to participate. They were then directed to the street rating page. Each of the RCS questions was followed by the definitions of the four street types. Subsequently, their background information was collected in line with a confidentiality statement, which was provided by the researcher. From the day it was made accessible in the online system, the questionnaire had been promoted for 30 days with a total number of 153 valid responses received. The ratio of male to female participants was about 0.8 to 1, and the number of participants with related professional backgrounds (urban planning and design, landscape, architecture, etc.) was no more than 20% of the total number.

Meanwhile, the second stage employed an onsite survey to investigate users' evaluations of the current level of restorativeness of the four selected case-study streets. The on-site questionnaire survey was conducted in University Road, Sujiatun Road, Zhangwu Road and Guokang Road during lunch breaks on sunny weekdays in spring.

Participants were recruited at the site of each chosen street and according to the following requirements: (1) they were walking alone on the streets [30]; (2) they were aged between 22 and 55 and (3) they were not in a hurry. The information sheet and consent form had the same content as the online version, and were read and signed by all participants before the survey started. Participants were asked to walk in their usual manner (in terms of walking speed and glances) along the target street while answering the researchers' questions. The researchers deliberately walked behind the participants, and the participants were told not to turn their heads back toward the researchers when they heard their questions to prevent any visual influence. While walking, they were asked about their perceptions of the restorative benefits in the street, as measured by RCS. All participants walked within the same section in targeted streets, but their starting locations varied slightly (depending on where they were approached, and whether they wanted to walk to the predetermined starting points). The onsite survey took each participant 10–15 min. During the one-week period allocated for each street, 30 participants took part in the survey on Sujiatun Road (landscape and leisure street), 30 participated on University Road (commercial street), 31 participants agreed to take part on Guokang Road (traffic-oriented Street), and 30 participants undertook it on Zhangwu Road (living and service street). For each street, the ratio of male to female participants was controlled at a rate of about one to one, and the number of participants with relevant professional backgrounds did not exceed 20% of the total number.

3. Results

3.1. Data Characteristics

3.1.1. Manipulation Checks

The data were analyzed using SPSS V 26.0 and was examined for internal consistency with Cronbach's alpha [31]. This is a widely adopted method in environmental psychology research that allows researchers to calculate the internal consistency of the collected rating results. The α values of the four ART dimensions—*being away*, *extent*, *fascination*, and *compatibility*—in relation to the ratings of the four street types and four case-study streets showed a suitable level of internal consistency (the α value should be higher than 0.6); this guaranteed the reliability of the obtained RCS ratings (see Table 3).

Table 3. Internal Consistency Results of RCS Expectations and Current Ratings.

Street Type		CM				LL				LS				TO			
Expectation Results	ART Components	B	E	F	C	B	E	F	C	B	E	F	C	B	E	F	C
	Cronbach’s α	0.85	0.91	0.90	0.84	0.85	0.90	0.92	0.88	0.84	0.89	0.91	0.86	0.92	0.88	0.96	0.87
Current Results	No. of Participants	153															
	Cronbach’s α	0.71	0.60	0.82	0.76	0.94	0.63	0.76	0.76	0.86	0.60	0.85	0.66	0.70	0.70	0.88	0.75
No. of Participants		30				30				30				31			

B = being away; E = extent; F = fascination; C = compatibility; LL = landscape and leisure street; LS = living and service street; CM = commercial street; TO = traffic-oriented street.

3.1.2. General Descriptions of RCS Results

General descriptions of the expected and current levels of street restorativeness are shown in Tables 4 and 5.

Table 4. General Descriptions of the Expected Restorative Results as Measured by the RCS (N = 153).

LL	B1-LL	B2-LL	B3-LL	E1-LL	E2-LL	E3-LL	F1-LL	F2-LL	F3-LL	F4-LL	F5-LL	C1-LL	C2-LL	C3-LL	C4-LL	
Mean	5.71	5.67	5.29	5.39	5.56	5.48	5.50	5.44	5.67	5.88	5.79	5.53	5.48	5.54	5.48	
N	153															
Std. Deviation	1.28	1.29	1.50	1.33	1.26	1.32	1.40	1.45	1.27	1.31	1.18	1.37	1.40	1.31	1.38	
TO	B1-TO	B2-TO	B3-TO	E1-TO	E2-TO	E3-TO	F1-TO	F2-TO	F3-TO	F4-TO	F5-TO	C1-TO	C2-TO	C3-TO	C4-TO	
Mean	3.31	3.39	3.36	4.45	4.44	4.48	3.50	3.54	3.70	3.24	3.48	3.60	3.80	4.25	4.36	
N	153															
Std. Deviation	1.78	1.82	1.75	1.65	1.66	1.63	1.75	1.72	1.82	1.86	1.83	1.72	1.78	1.71	1.78	
CM	B1-CM	B2-CM	B3-CM	E1-CM	E2-CM	E3-CM	F1-CM	F2-CM	F3-CM	F4-CM	F5-CM	C1-CM	C2-CM	C3-CM	C4-CM	
Mean	4.60	4.40	4.18	5.03	4.92	4.98	5.07	5.08	5.10	4.84	4.57	4.60	4.54	4.76	5.10	
N	153															
Std. Deviation	1.54	1.51	1.68	1.34	1.40	1.37	1.42	1.48	1.39	1.44	1.56	1.56	1.51	1.44	1.30	
LS	B1-LS	B2-LS	B3-LS	E1-LS	E2-LS	E3-LS	F1-LS	F2-LS	F3-LS	F4-LS	F5-LS	C1-LS	C2-LS	C3-LS	C4-LS	
Mean	4.66	4.58	4.16	5.05	5.13	5.01	4.86	4.81	4.92	4.80	4.56	4.66	4.94	5.10	5.23	
N	153															
Std. Deviation	1.49	1.46	1.56	1.33	1.37	1.36	1.54	1.47	1.45	1.55	1.60	1.55	1.44	1.36	1.42	

B = being away; E = extent; F = fascination; C = compatibility; LL = landscape and leisure street; LS = living and service street; CM = commercial street; TO = traffic-oriented street.

Table 5. General Descriptions of the Current Restorative Results as Measured by RCS.

CM	CM-B1	CM-B2	CM-B3	CM-E1	CM-E2	CM-E3	CM-F1	CM-F2	CM-F3	CM-F4	CM-F5	CM-C1	CM-C2	CM-C3	CM-C4
Mean	4.23	3.77	2.83	4.33	4.43	3.87	4.30	3.93	4.57	4.43	4.20	4.30	4.07	4.67	4.63
N	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Std. Dev	1.17	1.17	1.53	1.09	0.97	1.22	1.47	1.62	1.07	1.43	1.10	1.32	1.20	0.76	0.96
LS	LS-B1	LS-B2	LS-B3	LS-E1	LS-E2	LS-E3	LS-F1	LS-F2	LS-F3	LS-F4	LS-F5	LS-C1	LS-C2	LS-C3	LS-C4
Mean	3.63	3.60	3.47	3.97	4.17	3.37	2.57	2.57	3.17	3.23	3.33	3.57	4.23	4.67	4.43
N	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Std. Dev	1.40	1.40	1.36	1.25	1.21	1.19	1.45	1.25	1.15	1.19	1.15	1.36	1.14	0.96	1.10

Table 5. *Cont.*

TO	TO-B1	TO-B2	TO-B3	TO-E1	TO-E2	TO-E3	TO-F1	TO-F2	TO-F3	TO-F4	TO-F5	TO-C1	TO-C2	TO-C3	TO-C4
Mean	3.23	3.16	2.77	4.42	4.06	3.42	2.65	2.58	3.06	2.74	3.26	3.52	4.10	4.84	3.90
N	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
Std. Dev	1.41	1.39	1.38	1.15	1.09	1.46	1.92	1.63	1.39	1.81	1.59	1.55	1.33	0.97	1.35
LL	LL-B1	LL-B2	LL-B3	LL-E1	LL-E2	LL-E3	LL-F1	LL-F2	LL-F3	LL-F4	LL-F5	LL-C1	LL-C2	LL-C3	LL-C4
Mean	4.40	3.83	3.27	4.47	4.63	3.77	3.30	3.10	4.17	4.50	3.97	4.77	4.37	5.17	4.53
N	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Std. Dev	1.13	1.37	1.31	0.82	1.03	1.79	1.51	1.58	1.21	1.48	1.56	0.94	1.03	0.75	1.28

B = being away; E = extent; F = fascination; C = compatibility; LL = landscape and leisure street; LS = living and service street; CM = commercial street; TO = traffic-oriented street.

3.1.3. Individual Perceptual Differences

Differences in the expected restorativeness between the groups were taken into consideration with regard to their professional backgrounds (professional and lay participants: two groups), their gender (male and female: two groups) and their ages (four groups). Overall, there was a level of consistency in terms of restorative expectations when comparing those with relevant professional backgrounds to those without them. Significant disparities were only found in the results relating to the traffic-oriented street; nine RCS items appeared to differ between the professional group and the lay participants. With regard to the influence of gender on individual perceptions, only one RCS item (C4) relating to the commercial street flagged up a noteworthy difference between male and female contributors. Additionally, very slight differences were observed between the four age groups in relation to the RCS items; however, significant differences did appear in relation to two items (B2, referring to people feeling free from other people’s demands and expectations, and F5, referring to people’s absorption in the surrounding environment) regarding the commercial street, and two items (B2, as above, and F4, referring to people’s inclinations towards lingering in this environment) linked to the living and service street (see Table 6). This can be explained by the fact that people’s interests and needs may change with age. For example, children prefer streets with more toy stores, while a teenager may expect open spaces for meeting with others. To conclude, the impact of perceptual differences on the accuracy of evaluation results was limited (Table 6).

Table 6. Individual Perceptual Differences in the Expectation Ratings Across Gender, Age and Professional Groups (Significance < 0.05). Source: the Author.

		Being Away			Extent			Fascination					Compatibility			
		B1	B2	B3	E1	E2	E3	F1	F2	F3	F4	F5	C1	C2	C3	C4
Professional groups	CM Street	0.62	0.16	0.34	0.67	0.88	0.93	0.91	0.36	0.49	0.30	0.45	0.72	0.56	0.62	0.54
	LS Street	0.11	0.04	0.27	0.30	0.50	0.61	0.81	0.50	0.77	0.58	0.82	0.46	0.33	0.92	0.94
	LL Street	0.04	0.12	0.05	0.17	0.20	0.02	0.03	0.03	0.01	0.24	0.09	0.08	0.13	0.25	0.00
	TO Street	0.00	0.00	0.00	0.02	0.01	0.01	0.00	0.01	0.00	0.00	0.25	0.14	0.51	0.20	0.01
Gender groups	CM Street	0.42	0.62	0.09	0.82	0.36	0.76	0.09	0.21	0.06	0.04	0.73	0.01	0.05	0.38	0.00
	LS Street	0.58	0.75	0.18	0.02	0.23	0.17	0.17	0.02	0.10	0.19	0.45	0.05	0.23	0.16	0.05
	LL Street	0.50	0.73	0.16	0.96	0.75	0.80	0.40	0.62	0.92	0.31	0.91	0.78	0.76	0.33	0.31
	TO Street	0.52	0.25	0.21	0.07	0.24	0.44	0.98	0.61	0.95	0.98	0.94	0.87	0.15	0.36	0.19
Age groups	CM Street	0.53	0.05	0.16	0.91	0.69	0.67	0.94	0.95	0.51	0.17	0.04	0.59	0.22	0.46	0.50
	LS Street	0.05	0.04	0.02	0.40	0.95	0.43	0.42	0.86	0.33	0.32	0.09	0.20	0.94	0.76	0.38
	LL Street	0.14	0.19	0.16	0.31	0.51	0.35	0.43	0.76	0.44	0.31	0.32	0.29	0.22	0.11	0.59
	TO Street	0.01	0.11	0.14	0.13	0.44	0.28	0.00	0.03	0.00	0.00	0.00	0.03	0.03	0.23	0.39

B = being away; E = extent; F = fascination; C = compatibility; LL = landscape and leisure street; LS = living and service street; CM = commercial street; TO = traffic-oriented street.

With regard to the rating results linked to current street restorativeness, very few RCS items were found to have significant differences in relation to the participants' differences in age, gender and professional status. Individual perceptual difference was therefore perceived as insignificant (Table 7).

Table 7. Individual Perceptual Differences in the Current Ratings Across Gender, Age and Professional Groups (Significance < 0.05).

		Being Away			Extent			Fascination					Compatibility			
		B1	B2	B3	E1	E2	E3	F1	F2	F3	F4	F5	C1	C2	C3	C4
Professional groups	University Road	0.33	0.01	0.41	0.60	0.83	0.90	0.90	0.88	0.48	0.17	0.21	0.88	0.96	0.65	0.60
	Zhangwu Road	0.18	0.71	0.42	0.11	0.25	0.35	0.94	0.80	0.17	0.51	0.72	0.50	0.77	0.94	0.33
	Sujiatun Road	0.91	0.53	0.92	0.79	0.77	0.93	0.96	0.75	0.31	0.95	0.97	0.15	0.38	0.43	0.21
	Guokang Road	0.50	0.40	0.01	0.27	0.42	0.21	0.90	0.26	0.52	0.26	0.14	0.30	0.35	0.11	0.30
Gender groups	University Road	0.33	0.01	0.41	0.60	0.83	0.90	0.90	0.88	0.48	0.17	0.21	0.88	0.99	0.65	0.60
	Zhangwu Road	0.05	0.41	0.19	0.22	0.12	0.61	0.59	0.37	0.90	0.39	0.85	0.09	0.09	0.46	0.42
	Sujiatun Road	0.84	0.23	0.27	0.52	0.10	0.22	0.13	0.58	0.35	0.02	0.08	0.02	0.36	0.60	0.92
	Guokang Road	0.92	0.98	0.01	0.52	0.18	0.29	0.55	0.09	0.09	0.35	0.16	0.20	0.23	0.10	0.23
Age groups	University Road	0.23	0.07	0.18	0.65	0.49	0.23	0.22	0.59	0.23	0.78	0.88	0.67	0.09	0.89	0.33
	Zhangwu Road	0.29	0.29	0.57	0.72	0.41	0.97	0.78	0.11	0.24	0.01	0.66	0.32	0.59	0.39	0.94
	Sujiatun Road	0.09	0.41	0.66	0.97	0.76	0.12	0.08	0.55	0.19	0.10	0.29	0.31	0.71	0.65	0.47
	Guokang Road	0.31	0.97	0.18	0.35	0.33	0.76	0.53	0.09	0.15	0.43	0.02	0.01	0.85	0.23	0.67

B = being away; E = extent; F = fascination; C = compatibility.

3.2. The Difference between the Expected and the Current Levels of Street Restorativeness

The RCS mean rating results suggested that the current restorativeness of the four case-study streets barely met the users' expectations in terms of almost all of the ART dimensions, except in relation to the *compatibility* dimension of Guokang Road (traffic-oriented street). Meanwhile, the largest disparity between people's expectations and the current level of restorativeness was observed with regard to the landscape and leisure street (*mean dif.* = 1.39), followed by the living and service street (*mean dif.* = 1.17) and the commercial street (*mean dif.* = 0.63), while the traffic-oriented street exhibited the smallest variance (*mean dif.* = 0.33) (see Figure 9).

ANOVA analysis was also conducted to extrapolate the level of difference between the expected and current restorative ratings across four street groups (the landscape and leisure street type and Sujiatun Road; the commercial street type and University Road; the traffic-oriented street type and Guokang Road and the living and service street type and Zhangwu Road), which can be utilized to indicate the necessary degree of design intervention. The most significant variances (*sig.* < 0.01) between the expected and current restorative ratings were observed in relation to the *compatibility* dimension of the landscape and leisure street (*sig.* = 0.002), the *being away* dimension of the traffic-oriented street (*sig.* = 0.000) and the *fascination* dimension of the living and service street (*sig.* = 0.006). Obvious differences (*sig.* < 0.05) also appeared in relation to the *extent* dimension of the traffic-oriented street (*sig.* = 0.013) and the *extent* (*sig.* = 0.013) and *compatibility* (*sig.* = 0.021) dimensions of the commercial street (see Table 8).

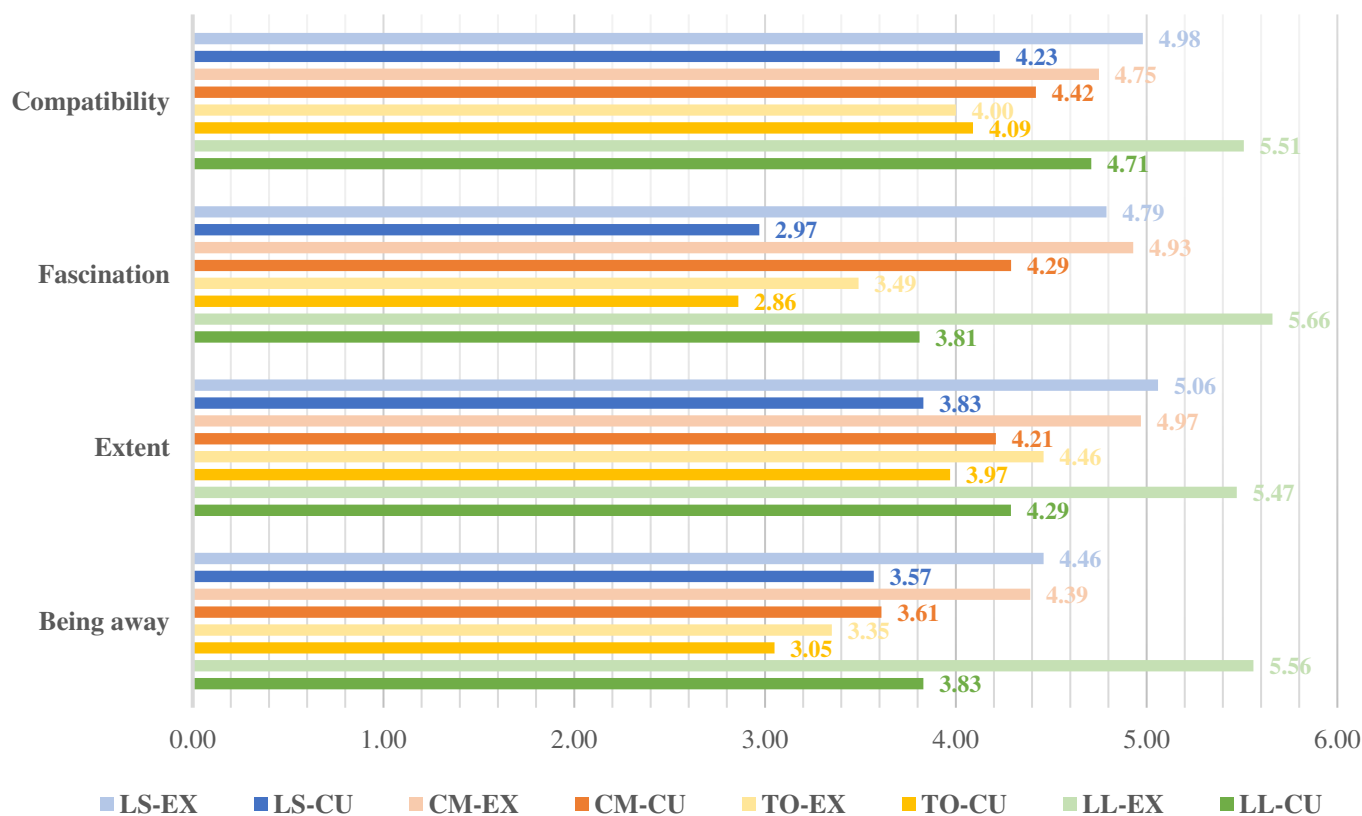


Figure 9. Comparing the expected and current restorative ratings across four street groups (N-EX = 153, N-CU/LL = 30; N-CU/TO = 31; N-CU/CM = 30; N-CU/LS = 30). (LL = landscape and leisure street; LS = living and service street; CM = commercial street; TO = traffic-oriented street; EX = expectation; CU = current. Source: the author).

Table 8. The Level of Difference Between the Expected and Current Restorative Ratings Across Four Street Groups. (Source: the author).

Street Type	Restorativeness	Being Away	Extent	Fascination	Compatibility
Landscape and Leisure Street (Sujiatun Road)	Current restorativeness (N = 30)	3.83	4.29	3.81	4.71
	Std. Dev	1.13	0.96	1.17	0.72
	Expected restorativeness (N = 153)	5.56	5.47	5.66	5.51
	Std. Dev	1.20	1.19	1.16	1.18
Traffic-oriented Street (Guokang Road)	Current restorativeness (N = 31)	3.05	3.97	2.86	4.09
	Std. Dev	1.10	0.98	1.38	0.99
	Expected restorativeness (N = 153)	3.35	4.46	3.49	4.00
	Std. Dev	1.66	1.48	1.66	1.48
Commercial Street (University Road)	Current restorativeness (N = 30)	3.61	4.21	4.29	4.42
	Std. Dev	1.04	0.80	1.03	0.83
	Expected restorativeness (N = 153)	4.39	4.97	4.93	4.75
	Std. Dev	1.39	1.26	1.23	1.20
Living and Service Street (Zhangwu Road)	Current restorativeness (N = 30)	3.57	3.83	2.97	4.23
	Std. Dev	1.31	0.92	0.89	0.87
	Expected restorativeness (N = 153)	4.46	5.06	4.79	4.98
	Std. Dev	1.31	1.23	1.31	1.21
	Sig.	0.64	0.12	0.01	0.10

4. Design Implications for the Case-Study Streets

This study intended to develop restorative street-design instructions by comparing the differences between the expected and current degree of street restorativeness. This involved collating four street types and their corresponding case-study streets in Shanghai as examples. These comprised the landscape and leisure street/Sujiatun Road, the commercial street/University Road, the traffic-oriented street/Guokang Road and the living and service street/Zhangwu Road. The mean ratings of the RCS expectations and the current results were employed to indicate whether the case-study streets needed to be improved, while the level of significance was used to determine the necessary level of design interventions.

In all four ART dimensions, the results show that the current restorativeness qualities of Sujiatun Road are lower than the expectation levels of users, which suggests that comprehensive improvements are necessary. In terms of the degree of intervention, the *compatibility* dimension requires the strongest level of improvement in Sujiatun Road in order to meet users' expectations, while only slight efforts are needed with regard to the other three dimensions. Furthermore, regarding existing evidence on the relationship between ART dimensions and environmental qualities, street design instructions to improve the restorativeness of Sujiatun Road may include the following changes. (1) An enhancement to the sense of *extent* should be undertaken by improving the openness [32] and unity [33] of Sujiatun Road, which can be achieved by reducing the amount of streetside vegetation or increasing the frequency of pruning, and the provision of street facilities should also be reconsidered, as they are currently too concentrated on this street. (2) To improve the sense of *fascination* by strengthening the cohesiveness [34,35] of Sujiatun Road, thematic design concepts linked to the current open spaces located along both sides of the street can also be applied. With meticulous design, these open spaces might not only sustain their current capabilities in relation to daily leisure activities, but they could also become an outstanding landmark for Sujiatun Road that could welcome more spontaneous and temporary activities. (3) To improve the sense of *compatibility*, street facilities with more diverse functions—for example, the introduction of commercial frontages including cafes, bookstores and flower markets—are essential, as existing facilities mostly apply to fitness and resting activities.

As for University Road, its restorative dimensions of *being away*, *extent*, *fascination* and *compatibility* should also be improved, according to the rating results. The comparison between the expected and current RCS rating results revealed that exhaustive interventions should be made in relation to the *extent* and *compatibility* dimensions. Meanwhile, according to the findings, the *being away* and *fascination* dimensions require a relatively small number of design improvements. With regard to existing evidence about the relationship between ART dimensions and environmental qualities, street-design instructions to improve the restorativeness of University Road may incorporate the following elements. (1) To improve the sense of *extent* by adjusting users' perceived levels of street openness [32], more hedgerows should be planted behind the south side of the university fences. Planting trees in a continuous row along the west side of the street may also be helpful. (2) To progress the sense of *compatibility*, more diverse uses of street frontages should be encouraged; that is, opportunities should be provided for street users to fulfil their normal daily demands.

The current restorativeness rating of the *compatibility* dimension in relation to Guokang Road exceeded expectations. Indeed, it was the one category that had a higher current restorative rating than its expectation rating, not only in terms of the street pair of Guokang Road and the traffic-oriented street type, but in relation to all four of the street pairings. However, the other three dimensions relating to Guokang Road did not meet the users' expectations. In fact, the results generally suggest that the restorativeness of Guokang Road should be improved, but the design should primarily focus on the dimensions of *being away*, *extent* and *fascination*. With regard to *being away* and *extent*, a strong level of improvement is necessary, while a lower level of progression is needed in terms of *fascination*. Hence, street design instructions to improve the restorativeness of Guokang Road should mainly

focus on improving the sense of *being away* and *extent*, and these measures might include: (1) adjusting the appearance of street openness [32] by planting more hedgerows behind the south side of the university fences, and (2) encouraging a more diverse use of street frontages to encourage more variation in streetside vegetation, including the use of seasonal flowers and a variety of designs in the flower beds.

The current restorativeness level of Zhangwu Road, as measured by the RCS, is slightly lower than its expectation level in terms of all ART dimensions, which means improvements should be made with regard to *being away*, *extent*, *fascination*, and *compatibility*. Among these dimensions, *fascination* requires the strongest level of design improvement, while slight interventions can be made in relation to the other three in order to meet users' expectations. Consequently, street-design instructions to improve the restorativeness of Zhangwu Road should mainly focus on improving the sense of *fascination*, which may include: (1) using more diverse vegetation types, (2) designing more varied forms of streetside greenery pools, and (3) providing necessary and mixed street and streetside facilities.

5. Discussion and Conclusions

Aside from defining the difference between urban streets and conventional restorative settings, street restorativeness is regarded as an environmental quality that must be fulfilled in line with considerations of other street qualities linking to their inherent functions. This study explored an expectation-current approach to optimizing street restorativeness under this prerequisite, using the difference between users' expectations and their evaluations of current levels of street restorativeness to illuminate optimization objectives and to form conclusions on the design implications. Four typical street types in Shanghai and their corresponding case-study streets were measured and compared with this approach, which was composed of an online questionnaire, an on-site survey and mathematic analysis. Individual perceptual differences were also tested, both with regard to the expected and current restorativeness RCS ratings, and the results show that there are generally no perception-related differences across different professional backgrounds, ages and genders. The research results have been thereby proven to be reliable.

Even though the results successfully revealed the gaps between the current situation and people's expectations in terms of the restorativeness levels of the streets, and design implications were provided according to these gaps, some limitations do exist in relation to the design and implementation of this research. First, the RCS measures human restorative perception, yet it cannot offer restorative cues relating to environmental attributes; that is, the gaps between the expected and current restorativeness levels cannot be efficiently translated into a specific design language. In this study, pertinent design evidence was obtained by tracing back within the relevant literature, which can be time-consuming and is also strictly restricted by existing evidence corresponding to environmental attributes and restorative perceptions. Furthermore, there was a major difference between the number of people who participated in the on-site survey and the number of individuals who contributed to the online survey, due to constraints on time, finances and experimental design; this may also affect the accuracy of the obtained rating results to a certain extent.

To conclude, this research innovatively proposed an expectation-current approach, using the difference between street restorativeness expectations and current levels of restorativeness to indicate in what ways and how much street restorative benefits could be optimized. This was achieved while considering street functions and typologies, since the delivery of street restorativeness should not privilege quantity over quality. The application of the expectation-current approach to four pairs of case-study streets revealed its ability to improve street restorativeness in an effective, economical and rigorous manner. The formalization of this approach can potentially be employed in relation to broader environmental assessment studies, especially where the environmental quality under assessment is closely linked to the users' perceptions and experiences. Moreover, by fostering a deeper appreciation of users' wishes and using them to set the optimization

standard, this study further weakens the detrimental bias brought about by the ‘paternalism and familism’ that have been rooted in the planning and design arena for decades [36].

Author Contributions: Conceptualization, K.T. and Y.Y.; methodology, K.T. and Y.Y.; software, Y.Y.; validation, Y.Y. and Y.S.; formal analysis, Y.Y.; investigation, Y.Y.; resources, Y.S.; data curation, Y.Y.; writing—original draft preparation, Y.Y.; writing—review and editing, Y.Y. and Y.S.; visualization, Y.Y.; supervision, K.T. and Y.S.; project administration, K.T. and Y.S.; funding acquisition, Y.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Nature Science Foundation of China: 51808393; Shanghai Post-doctoral Excellence Program: 2021357; Restorative Urbanism Research Center (RURC), Joint Laboratory for International Cooperation on Eco-Urban Design, Tongji University (CAUP-UD-06).

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Tongji University (protocol code 2020tjdx075 and date of approval 9 November 2020).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Acknowledgments: We would like to express our deepest appreciation to those who participated in the survey and to students who helped during the survey.

Conflicts of Interest: The authors declare no conflict of interest.

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